"Express Mail" Mailing Label No.: EV 331534003 US

Date of Deposit: July 2, 2003

ATTORNEY DOCKET NO. 14885US01

# METHOD AND SYSTEM FOR SECURE AUTOMATIC MEDIA DEPENDENT INTERFACE RECONFIGURATION AND REPAIR

## CROSS-REFERENCE TO RELATED APPLICATIONS/INCORPORATION BY REFERENCE

**[01]** This application makes reference to United States Patent Application Serial No. _____ (Attorney Docket No. 14227US01) entitled "Method and System for Secure Automatic Media Dependent Interface Reconfiguration and Repair," which is filed concurrently herewith and incorporated herein by reference in its entirety.

## FIELD OF THE INVENTION

**[02]** Certain embodiments of the invention relate to communications media configuration. More specifically, certain embodiments of the invention relate to a method and system for secure automatic media dependent interface (MDI) reconfiguration and repair.

## BACKGROUND OF THE INVENTION

**[03]** The coupling and configuration of two interfaces in a communication system is generally critical to the operation of devices whose interfaces are being coupled. In some instances, improper coupling or configuration may result in one or more of damaged equipment, malfunctioning equipment and system failure. Particularly in systems which lack redundancy, improper coupling or configuration may, in certain instances, render a system or specific sub-system inoperable. In order to mitigate the effects of improper coupling and configuration, various techniques and methodologies have been implemented. Automatic media dependent interface (MDI) crossover (Auto-MDIX), Ethernet@wirespeed and cable diagnostics, for example, provide ways for

eliminating or otherwise mitigating certain effects that result from improper coupling or configuration.

**[04]** In a typical 4-pair conductor or wire system, auto-MDIX may be adapted to automatically detect the order of media pairs 1 and 2 and in certain instances, auto-MDIX may reconfigure only certain channels so as to properly re-assign the transmit/receive media pairs to these channels. Auto-MDIX may also be adapted to reconfigure channel ordering for certain channels in order to mitigate the effects of improper interfacing and/or configuration. In 1000 Base-T mode for example, auto-MDIX may reconfigure the operational mode of media pairs 3 and 4 in accordance with or dependent on the order of media pairs 1 & 2. Auto-MDIX may eliminate a need for crossover cables which may be utilized between hubs and routers, for example. Finally, auto-MDIX may simplify installation in certain applications since the wiring order of a cable plant does not have be known.

**[05]** Notwithstanding, Auto-MDIX is limited to reconfiguring only media pairs 1 and 2 and media pairs 3 and 4. In particular, auto-MDIX relies on a basic assumption that media pairs 1 & 2 are wired respectively and media pairs 3 & 4 are wired respectively. Accordingly, a major drawback with auto-MDIX is that auto-MDIX does not operate on other combinations of wiring configurations. For example, auto-MDIX does not operate on media pairs 1 and 3 or media pairs 2 and 4 and as a result, may be able to reconfigure and/or correct an improper installation involving media pairs 1 and 3 and media pairs 2 and 4. Another disadvantage of auto-MDIX is that it operated on a basic assumption that media pairs 1 and 2 are wired respectively and media pairs 3 & 4 are wired respectively.

**[06]** On the contrary, Ethernet@wirespeed provides an algorithm that is adapted to detect the conditions on the media and/or the coupling interface and to select and implement an appropriate methodology for mitigating the effects of improper cabling or interfacing. In this regard, Ethernet@wirespeed may be adapted to automatically down shift or reduce transmission speed whenever optimal transmission cannot be maintained or supported due to impairments in the channel characteristics, which may

be caused by improper cabling or interfacing. Ethernet@wirespeed may be particularly useful in cases where channel or media characteristics have degraded but the channel or media is still required for providing communication. For example, in 1000 Base-T applications, the conditions on the media may deteriorate to a point where 1000 Base-T operational speeds cannot be sustained, but the channel cannot be taken out of service because it is needed for providing data communication. As a result, 10/100 Base-T service may be provided. One drawback with Ethernet@wirespeed is that it does not operate on a broken or damaged media pair 1 or media pair 2 in a cable plant. Moreover, Ethernet@wirespeed does not have the capability to reconfigure wire pairs in order to utilize other good pairs in the cable plant. For example, in a case where media pair 3 or pair 4 may be unused, Ethernet@wirespeed does not have the capability to reconfigure media pair 3 or media pair 4 for communication.

**[07]** In contrast, cable diagnostics may be adapted to provide information pertaining to the quality of a cable plant. In this regard, cable diagnostics may detect whether there is, for example, an open, short or proper termination on the cable or media. Cable diagnostics may be adapted to determine, for example, the length of the cable plant or media, and provide information regarding a location of an impedance mismatch in the cable plant. Notwithstanding, cable diagnostics does not have the capability to determine whether the cable plant has been incorrectly installed. For example, in a case where media pair 1 and media pair 3 are swapped but all the termination points are correct, cable diagnostics does not have the capability to detect and report the swapped cable condition. In this case, cable diagnostics will report that all is copasetic, even though media pair 1 has been swapped with media pair 3.

**[08]** Various standards such as 10 Base-T, 100 Base-T and 1000 Base-T have been developed to provide communications over unshielded twisted pair. For example, 1000 Base-T was developed to provide data communication at speeds of the order of 1 Gigabits per second (Gbps) over category-5 (CAT-5) unshielded twisted pair (UTP) wire or cable. The 1000 Base-T standard defines a five (5) level pulse amplitude modulated signal that may be transmitted the CAT-5 wiring. In this regard, a 1000 Base-T

transceiver may be adapted to transmit data at a rate of 125 megasymbols over each pairs in a 4 media pair in a CAT-5 wire or cable. Since each 125 megasymbol carries 250 megabits per second, the effective rate over four (4) media pairs is one gigabit per second.

**[09]** To mitigate the effects of interference such as near-end crosstalk, far-end crosstalk, echo and attenuation resulting from use of the unshielded twisted pair, a 1000 Base-T transceiver may include an analog front end (AFE). The analog front end may include, but is not limited to, analog-to-digital converters (ADCs), digital-to-analog converters (DACs) and amplifiers. These devices that may be required to implement the analog front end may require additional chip area, which increases the size of the transceiver chip.

**[10]** FIG. 1 is a block diagram of a conventional auto-MDIX system, which utilizes four (4) media pairs. Referring to FIG. 1, there is shown a first AFE 102 which is a 10/100/1000 Base-T AFE, a second AFE 104 which is a 10/100/1000 Base-T AFE, a third AFE 106 which is a 1000 Base-T AFE, a fourth AFE 108 which is a 1000 Base-T AFE, a first auto-MDIX controller 110 and a second auto-MDIX controller 112. The first AFE 102 may be coupled to a first media pair and the second AFE 104 may be coupled to a second media pair. The third AFE 106 may be coupled to a third media pair and the fourth AFE 108 may be coupled to a fourth media pair. The first auto-MDIX controller 110 is coupled to a channel A transmit/receive data signal and a channel B transmit/receive data signal. The second auto-MDIX controller 112 is coupled to a channel C transmit/receive data signal and a channel D transmit/receive data signal. Although AFEs 106, 108 are represented as 1000 Base-T AFEs, they may be configured to provide additional 10/100 Base-T functionality.

**[11]** Notwithstanding, in the auto-MDIX configuration of FIG. 1, the first controller 110 operates independent of the second controller 112. The first controller 110 may only control the coupling or cross-connect of channel A or channel B to any of only the first media pair or the second media pair. Similarly, the second controller may only control the coupling or cross-connect of channel C or channel D to any of only the first media

pair or the second media pair. Accordingly, the first controller 110 cannot cross-connect channel A or channel B to any of the third media pair or the fourth media pair and the second controller 112 cannot cross connect channel C or channel D to any of the first media pair or the second media pair.

**[12]** Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of such systems with some aspects of the present invention as set forth in the remainder of the present application with reference to the drawings.

## BRIEF SUMMARY OF THE INVENTION

**[13]** Certain embodiments of the invention may include a method and system for providing and configuring secure communication links. The method for providing and configuring secure communication links may include determining or choosing any one usable media pair from all existing media pairs of a first device. Any one channel may be selected from all existing channels so that the selected channel is different from a general channel assignment corresponding to the determined usable media pair. The selected channel may be assigned to the media pair. A second device may be notified of the assigned channel which corresponds to the media pair chosen from all the media pairs. The second device may cross-connect a corresponding channel and media pair which is equivalent to the selected channel assigned to the media pair. The method may also include negotiating the assignment of the selected channel to any one of the media pairs. A particular one of the channel and media pair assignments may be selected from a plurality of predetermined channel and media pair assignments.

**[14]** A first combination of the previously assigned channel and media pair may be designated as a communication channel and media pair. Similarly, a second combination of the channel and the previously assigned media pair may be designated as a communication channel and media pair. Communication traffic may be securely transferred via the communication channel and media pair. Similarly, control information may be securely transferred via the control channel and media pair and/or the communication channel and media pair. A second device may be adapted to monitor the communication channel and media pair and/or the control channel and media pair in order to determine the selected channel and media pair assignment utilized by the first device. The control information may include, but is not limited to, authentication information, encryption information, channel setup information, link provisioning and/or link maintenance information.

**[15]** Another embodiment of the invention may provide, a machine-readable storage, having stored thereon a computer program having at least one code section for

providing and configuring secure communication links. The at least one code section may be executable by a machine, thereby causing the machine to perform the steps for providing and configuring secure communication links.

**[16]** The invention may also provide a system for configuring communication links. The system may include at least one controller which may be adapted to determine a usable media pair from all existing media pairs. The controller may be adapted to select any channel from all existing channels. The controller may select the channel so that it is different from a general channel assignment corresponding to the determined usable media pair. At least one selector may be adapted to select a channel that may be assigned to the media pair. The controller may be configured to notify a second device of the assigned channel which corresponds to the media pair chosen from all the media pairs. A second controller and/or selector associated with the second device may cross-connect a corresponding channel and media pair which is equivalent to the selected channel assigned to the media pair. The controllers associated with each of the first and second devices may also negotiate the assignment of the selected channel to any one of the media pairs. The selector may select a particular one of the channel and media pair assignments which may be selected from a plurality of predetermined channel and media pair assignments.

**[17]** A first combination of the previously assigned channel and media pair may be designated as a communication channel and media pair. Similarly, a second combination of the channel and the previously assigned media pair may be designated as a communication channel and media pair. The controller associated with the first device may be configured to securely transfer communication traffic via the communication channel and media pair. Similarly, the controller may be adapted to securely transfer control information via the control channel and media pair or the communication channel and media pair. The second controller associated with the second device may monitor the communication channel and media pair and/or the control channel and media pair in order to determine the selected channel and media pair assignment utilized by the first device. The control information may include, but is

not limited to, authentication information, encryption information, channel setup information, link provisioning and link maintenance information.

**[18]** These and other advantages, aspects and novel features of the present invention, as well as details of an illustrated embodiment thereof, will be more fully understood from the following description and drawings.

## BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

**[19]** FIG. 1 is a block diagram of a conventional auto-MDIX system, which utilizes four (4) media pairs.

**[20]** FIG. 2 is a block diagram of an automatic MDI reconfigure and repair system, which utilizes four (4) media pairs in accordance with an embodiment of the invention.

**[21]** FIG. 3 is a block diagram of an automatic media dependent interface reconfigure and repair system, which may provide full Gigabit four (4) media pairs auto-MDIX in accordance with an embodiment of the invention.

**[22]** FIG. 4 is a block diagram of an automatic media dependent interface reconfigure and repair system, which may provide flip port assignment in accordance with an embodiment of the invention.

**[23]** FIG. 5 is an exemplary system for providing and configuring communication links in accordance with an embodiment of the invention.

**[24]** FIG. 6 is a block diagram of an exemplary scrambled channel and media pair assignment for a secure automatic MDI reconfigure and repair system in accordance with an embodiment of the invention.

**[25]** FIG. 7 is a block diagram of another exemplary assignment for a secure automatic media dependent interface reconfigure and repair system in accordance with an embodiment of the invention.

**[26]** FIG. 8 is a block diagram of an exemplary control and data channel and media pair assignment for a secure automatic MDI reconfigure and repair system in accordance with an embodiment of the invention.

**[27]** FIG. 9 is a block diagram of an exemplary control and data channel and media pair assignment for a more secure automatic MDI reconfigure and repair system in accordance with an embodiment of the invention.

**[28]** FIG. 10 is a block diagram of an exemplary end-to-end automatic MDI reconfigure and repair system in accordance with an embodiment of the invention.

## DETAILED DESCRIPTION OF THE INVENTION

**[29]** Aspects of the invention may include a method and system for providing and configuring secure communication links. The method may include determining or choosing any usable media pair from all existing media pairs of a first device. Any channel may be selected from all existing channels and the selected channel is chosen so that it is different from a general channel assignment corresponding to the determined usable media pair. The selected channel may be assigned to the media pair. A second device may be notified of the assigned channel which corresponds to the media pair chosen from all the media pairs. The second device may cross-connect a corresponding channel and media pair which is equivalent to the selected channel assigned to the media pair for the first device. The first and second device may be adapted to negotiate the assignment of the selected channel to any one of the media pairs. Alternatively, a particular channel and media pair assignment may be selected from a plurality of predetermined channel and media pair assignments and utilized by the first and second device.

**[30]** A first combination of the previously assigned channel and media pair may be designated as a communication channel and media pair. Similarly, a second combination of the channel and the previously assigned media pair may be designated as a communication channel and media pair. Communication traffic may be securely transferred via the communication channel and media pair. Similarly, control information may be securely transferred via the control channel and media pair and/or the communication channel and media pair. A second device may be adapted to monitor the communication channel and media pair and/or the control channel and media pair in order to determine the selected channel and media pair assignment utilized by the first device. The control information may include, but is not limited to, authentication information, encryption information, channel setup information, link provisioning and/or link maintenance information.

**[31]** Further aspects of the invention provide a method and system for automatic media dependent interface (MDI) reconfiguration and repair (AMRR) which may be used to provide and configure communication links. A method for providing and configuring communication links may include determining a usable media pair from all existing media pairs and selecting any one channel from all existing channels. The selected channel may be assigned to any one of the media pairs. Any one or any combination of media pairs may be monitored in order to detect the existence of a communication signal on any of the media pairs. Some or all of the existing media pairs may be monitored to determine which of the media pair may be capable of facilitating communication at a maximum communication speed and if not, at a reduced speed. Any selected channel may be cross-connected to any one of the existing media pairs, which may be capable of facilitating communication at the maximum or reduced communication speed

**[32]** In another embodiment of the invention any channel and media pair assignment of a previously defined general channel and media pair configuration, which defines channel and media pair assignments for at least a portion of all the existing media pairs, may be flipped or otherwise rearranged or re-assigned. Subsequent to flipping, the flipped channel and media pair assignment may be defined as a default channel and media pair configuration. In another aspect of the invention, a status of at least one of the existing media pairs and/or one of the existing channels may be defined. The status of the existing media pairs and/or the existing channels may be stored in one or more registers.

**[33]** In one embodiment of the invention, automatic MDI reconfigure and repair may be adapted to detect at least one available and/or usable media pair, determine proper channel assignments for each of a plurality media pairs and automatically assign any of a plurality of channels to the available or usable media pair. In assigning the channel to the media pairs, automatic MDI reconfigure and repair may be adapted to assign any channel to any available or usable media pairs. Automatic MDI reconfigure and repair may be adapted to monitor, detect and automatically reconfigure available or usable

media pairs to provide optimal communication. In this regard, automatic media dependent interface reconfigure and repair may be adapted to select available or usable media pairs so that a maximum throughput or communication speed may be attained.

**[34]** FIG. 2 is a block diagram of an automatic MDI reconfigure and repair system, which utilizes four (4) media pairs in accordance with an embodiment of the invention. Referring to FIG. 2, there is shown a first 10/100/1000 Base-T AFE 202, a second 10/100/1000 Base-T AFE 204, a third 10/100/1000 Base-T AFE 206, a fourth 10/100/1000 Base-T AFE 208, a single controller 210 and a register 212. The first AFE 202 may be coupled to a first media pair and the second AFE 204 may be coupled to a second media pair. Similarly, the third AFE 206 may be coupled to a third media pair and the fourth AFE 208 may be coupled to a fourth media pair. The single controller 210 may be coupled to channel A's transmit/receive data signal, channel B's transmit/receive data signals, channel C's transmit/receive data signals and channel D's transmit/receive data signals.

**[35]** In accordance with an embodiment of the invention, the single controller 210 may be adapted to cross connect or couple channels A, B, C or D to any of the media pairs 1, 2, 3 or 4. In this regard, channel A data signals may be coupled to any of media pairs 1, 2, 3 or 4 and channel B data signals may be coupled to any of media pairs 1, 2, 3 or 4. Similarly, channel C data signals may be coupled to any of media pairs 1, 2, 3 or 4 and channel D data signals may be coupled to any of media pairs 1, 2, 3 or 4. The controller arrangement of FIG. 2 therefore provides independent channel to media pair cross connect for all of the channels and all of the media pairs.

**[36]** In another embodiment of the invention, controller 210 may be configured to set or clear one or more bits in register 212. The bits in the register 212 may be utilized to indicate a current cross connect status of the automatic MDI reconfigure and repair system. In this regard a host processor or controller 210, for example, may be adapted to read appropriate portions of register 212 in order to determine an automatic media dependent interface reconfigure and repair connection status. Additionally, one or more bits in the control register may be used to specify or establish a particular cross connect

configuration. Accordingly, an external processor may be adapted to set or clear certain bits in the register 212 to indicate a desired cross-connection for a particular channel and media pair. The controller 212 may subsequently read the register 212 and configure the desired cross-connect arrangement. In another aspect of the invention, the automatic MDI reconfigure and repair system may indicate which of the media pairs are available and currently active or in use. The automatic MDI reconfigure and repair status may also provide an indication of which channels may be cross-connected or coupled to which of the media pairs and/or which media pairs are available or unavailable. The status of each channel, media pair and/or cross-connection may be written to the register 212 by controller 210.

**[37]** FIG. 3 is a block diagram of an automatic media dependent interface reconfigure and repair system, which may provide full Gigabit four (4) media pairs auto-MDIX in accordance with an embodiment of the invention. Referring to FIG. 3, there is shown a first 10/100/1000 Base-T AFE 302, a second 10/100/1000 Base-T AFE 304, a third 10/100/1000 Base-T AFE 306, a fourth 10/100/1000 Base-T AFE 308, a single controller 310 and a register 312. The configuration of FIG. 3 may be used to enhance the auto-MDIX configuration of FIG. 1 by providing connectivity between channel A data signals and media pair 3 and channel B data signals and media pair 4. This may overcome a major drawback of the auto-MDIX configuration of FIG. 1 where neither channel A nor B may be cross-connected or coupled to media pair 3 or media pair 4.

**[38]** In accordance with another embodiment of the invention, the controller 310 may be adapted to automatically determine the assignment of gigabit channels to media pairs, for example, when a cabling plant may be incorrectly installed. This may occur with greater frequency than in a two (2) media pair scenario since the greater number of conductors in the four (4) media pair case increases the likelihood of incorrect wiring. The automatic MID reconfigure and repair system configuration of FIG. 3 may provide arbitrary assignment of channel data to any media pair.

**[39]** In operation, the automatic MDI reconfigure and repair system may be adapted to monitor link pulses from the auto-MDIX pair and determine any existing channel A

and channel B assignments. The automatic MDI reconfigure and repair system may be adapted to auto-negotiate and determine the appropriate channel C and channel D assignments. In one aspect of the invention, the automatic MDI reconfigure and repair system may be adapted to utilize a trial-error method to determine the appropriate channel assignments. Notwithstanding, a status of the channel assignments for channels A, B, C and D may be denoted in register 312. Accordingly, a processor such as a host processor and/or controller 312 may be adapted to read the register 312 to determine the status of the channel assignments.

**[40]** In another aspect of the invention, a channel assignment/wiring order diagnostics may be provided. The channel assignment/wiring order diagnostics may be adapted to determine a status of each of the channels A, B, C, and D and a status of the media pairs 1, 2, 3 and 4. In this regard, controller 310 may determine the status of the channels and/or the media pairs and correspondingly update register 312 by setting and/or clearing corresponding bits in the status register. The register 310 may subsequently be read to determine the status of the channels and/or the media pairs. The channel assignment/wiring order diagnostics may be executed on a continuous basis or it may be executed at a specified interval. Notwithstanding, a current channel, media pair and/or cross connect status may be provided by the channel assignment/wiring order diagnostics.

**[41]** FIG. 4 is a block diagram of an automatic media dependent interface reconfigure and repair system, which may provide flip port assignment in accordance with an embodiment of the invention. Referring to FIG. 4, there is shown a first 10/100/1000 Base-T AFE 402, a second 10/100/1000 Base-T AFE 404, a third 10/100/1000 Base-T AFE 406, a fourth 10/100/1000 Base-T AFE 408, a single controller 410 and a register 412.

**[42]** In general, channel A may be assigned to media pair 1, channel 2 may be assigned to media pair 2, channel 3 may be assigned to media pair 3 and channel 4 may be assigned to media port 4. In accordance with an embodiment of the invention, controller 410 or an external processor may be adapted to configure register 412 to

establish a default assignment for each of the channels and/or the media pairs. In this regard, the general assignment of the channels to media pairs may be flipped to create a default channel and media pair assignment. Accordingly after flipping the channels/media pairs, channel A may be assigned to media pair 4, channel 2 may be assigned to media pair 3, channel 3 may be assigned to media pair 2 and channel 4 may be assigned to media port 1. In this case, the channel and media pairs may be flipped with respect to the general channel and media pair assignment. Notwithstanding, the invention is not limited in this regard and other default channel and media pair assignments other than the general channel and media pair assignment may be similarly defined.

**[43]** In accordance with an embodiment of the invention, the flip port assignment provided by the automatic MDI reconfigure and repair system may allow a single die or package to be used in legacy trace ordering of media pairs. In this regard, a single die or chip may be created for use by a plurality of customers, some of which may desire their own trace ordering on their printed circuit board (PCB). For example, the flip port assignment provided by the automatic MDI reconfigure and repair system may permit a single die or package to be utilized by a first customer requiring inline ordering and a second customer requiring mirror ordering. Moreover, flip port assignment may provide greater flexibility in the utilization of magnetics and connectors such as RJ45, without having to re-engineer and/or make significant board changes. For example, a customer may chose to place channel A on the right side of PCB and channel D on the left side of a PCB layout and/or package. Finally, the flip port assignment provided by the automatic MDI reconfigure and repair system in accordance with an embodiment of the invention may permit tapeout of a single die that can be used in die-up or die-down applications. This may be particularly important in, for example, flip-chip designs where package substrate cannot be customized to accommodate customer needs.

**[44]** FIG. 5 is an exemplary system for providing and configuring communication links in accordance with an embodiment of the invention. Referring to FIG. 5, there is shown a controller block 502 and a register block 510. The controller block 502 may include a

selector block 504, a detector block 508 and a monitor block 506. The selector block 504 may be a multiplexer that may be coupled to one or more media which may bear channels A, B, C and D. The selector block 504 may also be coupled to one or more media which may bear media pairs, namely media pairs 1, 2, 3 and 4. In this regard, there are four media pair shown. Notwithstanding, the invention is not so limited and other correspondingly more channels and/or media pairs may be handled by controller block 502 of the system. Although the selector block 504, monitor block 508 and detector block 506 are shown within controller block 502, the invention is not so limited and other arrangements may be possible. For example, any one or more of the selector block 504, monitor block 508 and detector block 506 may be located external to the controller block 502.

**[45]** The controller block 502 may be adapted to determine a usable media pair from all of the existing media pairs. The selector block 504 may facilitate the selection of any channel from all of the existing channels and the controller block 502 may assign the selected channel to any one of the selected media pairs. The controller block 502 may also be configured to determine at least one usable media pair from all of the existing media pairs. The detector block 506 may detect whether a communication signal is present on any one of the usable media pairs, namely media pairs 1, 2, 3, and 4. In this regard the detector block 506 may contain suitable logic and/or circuitry to detect pulses on any of the media pairs.

**[46]** In another aspect of the invention, the controller block 502 may determine which one of the existing media pairs may be capable of facilitating communication at a maximum or specified communication speed. The selector block 504 may subsequently cross-connect the selected channel to the existing media pair which is capable of facilitating communication at the maximum communication speed. Similarly, the controller block 502 may also determine which one of the existing media pairs may be capable of operating at a reduced communication speed relative to the maximum communication speed. The selector block 504 may subsequently cross-connect the selected channel to the existing media pair which is capable of operating at the reduced

communication speed. The selector block 504 may also be configured to flip any channel and media pair assignment of a previously defined general channel and media pair configuration, which defines channel and media pair assignments for at least a portion of the existing media pairs. The controller block 502 may then define the flipped channel and media pair assignment as a default channel and media pair configuration.

**[47]** The controller block 502 may be adapted to identify a status of at least one of the existing media pairs, at least one of the existing channels and at least one channel and media pair cross-connection. One or more registers in the register block 510 may store the identified status in one or more bit locations. Appropriate bit locations in at least one register in the register block 510 may be written to reflect changes to a media pair, a channel and/or a cross-connection. Similarly, appropriate bit locations in a register block 510 may be read to determine the status of a media pair, a channel and/or a cross-connection.

**[48]** United States patent application Serial No. _____ (Attorney Docket No. 14227US01) entitled "method and system for secure automatic media dependent interface (MDI) reconfiguration and repair" provides a description of link configuration in accordance with various aspects of the invention, and is incorporated herein by reference in its entirety.

**[49]** Generally, in a normal operational mode, channel 1 may be coupled or cross-connected to media pair 1, channel 2 may be coupled or cross-connected to media pair 2, channel 3 may be coupled or cross-connected to media pair 3 and channel 4 may be coupled or cross-connected to media pair 4. Accordingly, knowing that a first device utilizes the general channel and media pair assignments, a second device may replicate the general channel and media pair assignment in order to communicate with the first device. The invention provides a method and system for minimizing the chances of replicating channel and media pair assignments so that a second device may communicate with a first device. Consequently, a more secure communication link may be provided between the first and the second devices.

**[50]** In accordance with an embodiment of the invention, the cross-connection or coupling between any of the channels and the media pairs may be randomly arranged or scrambled to provide a secure high-speed communication between two (2) devices. During scrambling, a first controller adapted to control at least one of a first set of channel and media pairs associated with a first device may automatically negotiate with a second controller adapted to control at least one of a second set of channel and media pairs associated with a second device. In this regard, upon completion of the negotiation process, each of the channel and media pair assignments controlled by the first device's controller will be equivalent to channel and media pair assignments controlled by the second controller.

**[51]** FIG. 6 is a block diagram of an exemplary scrambled channel and media pair assignment for a secure automatic MDI reconfigure and repair system in accordance with an embodiment of the invention. Referring to FIG. 6, there is shown a first 10/100/1000 Base-T AFE 602, a second 10/100/1000 Base-T AFE 604, a third 10/100/1000 Base-T AFE 606, a fourth 10/100/1000 Base-T AFE 608, a single controller 610 and a register 612. In FIG. 6, the exemplary scrambled channel and media pair assignment shows channel B cross-connected to media pair 4, and channel D cross-connected to media pair 2. However, channel A is cross-connected to media pair 1 and channel C is cross connected to media pair 3, which is characteristic of the general channel and media pair assignment or configuration.

**[52]** FIG. 7 is a block diagram of another exemplary assignment for a secure automatic media dependent interface reconfigure and repair system in accordance with an embodiment of the invention. Referring to FIG. 7, there is shown a first 10/100/1000 Base-T AFE 702, a second 10/100/1000 Base-T AFE 704, a third 10/100/1000 Base-T AFE 706, a fourth 10/100/1000 Base-T AFE 708, a single controller 710 and a register 712. In FIG. 7, the exemplary scrambled channel and media pair assignment shows channel A cross-connected to media pair 4, and channel D cross-connected to media pair 1. However, channel B is cross-connected to media pair 2 and channel C is cross

connected to media 3, which is characteristic of the general channel and media pair configuration. Other scrambled channel and media pair assignments are also possible.

**[53]** In an alternate embodiment of the invention, a plurality of channel and media pair assignments may be predefined. The first device may select one of the plurality of channel and media pair assignments and cross-connect corresponding channels and media pairs as per the predefined assignment. A second device wanting to communicate with the first device may scan through each of the predefined assignments until it determines that a particular channel and media pair assignments are consistent with the channel and media pair assignment of the first device. The second device may then cross-connect one or more corresponding channels and media pair assignments consistent with one or more determined channels and media pair assignments. The first and the second device may then communicate using one or more corresponding cross-connected channels and media pair assignments.

**[54]** The predefined channel assignments may be stored in one or more registers that may be accessible by a controller, which may be configured to cross-connect or otherwise couple one or more channel and media pair assignments. Accordingly, the first device may have an associated register that may be adapted to store information related to the each of the pre-defined assignments and the second device may have an associated register that may be adapted to store information related to similar pre-defined assignments. Upon initiation of a communication session, for example, each controller may retrieve corresponding channel and media pair assignments information from its associated register.

**[55]** The following is a table illustrating exemplary predefined channel and media pair assignment, which may be stored in a memory or a register.

| Assignment 1 | | | | | Assignment 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ch A | Ch B | Ch C | Ch D | | Ch A | Ch B | Ch C | Ch D |
| Pr 1 | x | | | | Pr 1 | | x | | |
| Pr 2 | | x | | | Pr 2 | x | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pr 3 | | | x | | Pr 3 | | | x | |
| Pr 4 | | | | x | Pr 4 | | | | x |
| Assignment 3 | | | | | Assignment 4 | | | | |
| | Ch A | Ch B | Ch C | Ch D | | Ch A | Ch B | Ch C | Ch D |
| Pr 1 | | | x | | Pr 1 | | | | x |
| Pr 2 | | x | | | Pr 2 | | x | | |
| Pr 3 | x | | | | Pr 3 | | | x | |
| Pr 4 | | | | x | Pr 4 | x | | | |
| Assignment 5 | | | | | Assignment 6 | | | | |
| | Ch A | Ch B | Ch C | Ch D | | Ch A | Ch B | Ch C | Ch D |
| Pr 1 | x | | | | Pr 1 | x | | | |
| Pr 2 | | | x | | Pr 2 | | | | x |
| Pr 3 | | x | | | Pr 3 | | | x | |
| Pr 4 | | | | x | Pr 4 | | x | | |
| Assignment 7 | | | | | Assignment 8 | | | | |
| | Ch A | Ch B | Ch C | Ch D | | Ch A | Ch B | Ch C | Ch D |
| Pr 1 | x | | | | Pr 1 | | | | x |
| Pr 2 | | x | | | Pr 2 | | | x | |
| Pr 3 | | | | x | Pr 3 | | x | | |
| Pr 4 | | | x | | Pr 4 | x | | | |
| Assignment 9 | | | | | Assignment 10 | | | | |
| | Ch A | Ch B | Ch C | Ch D | | Ch A | Ch B | Ch C | Ch D |
| Pr 1 | | | x | | Pr 1 | | x | | |
| Pr 2 | | | | x | Pr 2 | | | x | |
| Pr 3 | | x | | | Pr 3 | | | | x |
| Pr 4 | x | | | | Pr 4 | x | | | |
| Assignment 11 | | | | | Assignment 12 | | | | |
| | Ch A | Ch B | Ch C | Ch D | | Ch A | Ch B | Ch C | Ch D |
| Pr 1 | x | | | | Pr 1 | | | | x |
| Pr 2 | | | x | | Pr 2 | | x | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pr 3 | | x | | | Pr 3 | | | x | |
| Pr 4 | | | | x | Pr 4 | x | | | |
| Assignment 14 | | | | | Assignment 13 | | | | |
| | Ch A | Ch B | Ch C | Ch D | | Ch A | Ch B | Ch C | Ch D |
| Pr 1 | | | | x | Pr 1 | | | | x |
| Pr 2 | | x | | | Pr 2 | x | | | |
| Pr 3 | | | x | | Pr 3 | | x | | |
| Pr 4 | x | | | | Pr 4 | | | x | |
| Assignment 15 | | | | | | | | | |
| | Ch A | Ch B | Ch C | Ch D | | | | | |
| Pr 1 | | | | x | | | | | |
| Pr 2 | | | x | | | | | | |
| Pr 3 | x | | | | | | | | |
| Pr 4 | | x | | | | | | | |

**[56]** Referring to the exemplary assignments in the table, assignment 1 may be the general assignment. In operation, during scrambling, any one of the predefined assignments 2-15 may be selected from the memory and the appropriate the channel and media pairs may be cross-connected. For example, in assignment 14, channel A may be cross-connected to media pair 4, channel B may be cross-connected to media pair 2, channel C may be cross-connected to media pair 3 and finally, channel D may be cross-connected to media pair 1. The channel and media pair assignments may be stored in memory as a lookup table.

**[57]** In an alternate embodiment of the invention, various channel and media pairs may be designated to be utilized as data communication channel and media pairs and others may be designated to be utilized as control channel and media pairs. In this regard, the communication channel and media pairs may transport communication traffic while the control channel and media pairs may transport control information. In one aspect of the invention, at least one data communication channel and media pair

may be selected and at least one control channel and media pair may be selected in order to facilitate communication between a first and a second device.

**[58]** FIG. 8 is a block diagram of an exemplary control and data channel and media pair assignment for a secure automatic MDI reconfigure and repair system in accordance with an embodiment of the invention. Referring to FIG. 8, there is shown a first 10/100/1000 Base-T AFE 802, a second 10/100/1000 Base-T AFE 804, a third 10/100/1000 Base-T AFE 806, a fourth 10/100/1000 Base-T AFE 808, a single controller 810 and a register 812. In FIG. 8, the exemplary control and data channel and media pair assignment illustrates channel A cross-connected to media pair 2, and channel B cross-connected to media pair 1. Furthermore, channel C is cross-connected to media pair 3 and channel D is cross connected to media 4 as in the general channel and media pair configuration. The channel A/media pair 2 and channel B/media pair 1 cross-connections may be designated as the communication channel and media pair assignment and the channel C/media pair 3 and channel D/media pair 4 cross-connections may be designated as the control channel and media pair assignments. Alternatively, the channel A/media pair 2 and channel B/media pair 1 cross-connections may be designated as the control channel and media pair assignment and the channel C/media pair 3 and channel D/media pair 4 cross-connections may be designated as the communication channel and media pair assignments.

**[59]** During initiation of a communication session, for example, between a first device and a second device, the control channel and media pairs may be utilized to securely transfer control information that may be required to establish and/or otherwise facilitate communication via the selected communication channel and media pair. Exemplary control information that may be transferred via the control channel and media pair may include, but is not limited to, authentication information, encryption information and channel setup parameters such as communication speed and protocol specific information. In one aspect of the invention, link specific information, for example, may be transferred from a first device to a second device via the control channel and media pair. In this regard, a particular control channel and media pair may be assigned as a

default control channel and media pair that may be monitored by a second device. The first device may communicate the control information via this default control channel and media pair, where it may be received by the second device.

**[60]** In another embodiment of the invention, the exemplary control and data channel and media pair assignment for a secure automatic MDI reconfigure and repair system may be enhanced by securing both the communication channel and media pair assignments and the control channel and media pair assignments. Accordingly, the control channel and media pair assignments may also be scrambled. FIG. 9 is a block diagram of an exemplary control and data channel and media pair assignment for a more secure automatic MDI reconfigure and repair system in accordance with an embodiment of the invention.

**[61]** Referring to FIG. 9, there is shown a first 10/100/1000 Base-T AFE 902, a second 10/100/1000 Base-T AFE 904, a third 10/100/1000 Base-T AFE 906, a fourth 10/100/1000 Base-T AFE 908, a single controller 910 and a register 912. In FIG. 9, the exemplary control and data channel and media pair assignment illustrates channel A cross-connected to media pair 2 and channel B cross-connected to media pair 1. Furthermore, channel C is cross-connected to media pair 4 and channel D is cross connected to media 3. The channel A/media pair 2 and channel B/media pair 1 cross-connections may be designated as the communication channel and media pair assignment and the channel C/media pair 4 and channel D/media pair 3 cross-connections may be designated as the control channel and media pair assignments. Alternatively, the channel A/media pair 2 and channel B/media pair 1 cross-connections may be designated as the control channel and media pair assignment and the channel C/media pair 4 and channel D/media pair 3 cross-connections may be designated as the communication channel and media pair assignments.

**[62]** FIG. 10 is a block diagram of an exemplary end-to-end automatic MDI reconfigure and repair system in accordance with an embodiment of the invention. Referring to FIG. 10, there is shown a first device 1000 which includes a first 10/100/1000 Base-T AFE 1002, a second 10/100/1000 Base-T AFE 1004, a third

10/100/1000 Base-T AFE 1006, a fourth 10/100/1000 Base-T AFE 1008, a single controller 1010, register block 1012 and a selector block 1014. FIG. 10 also depicts a second device 1050 which includes a first 10/100/1000 Base-T AFE 1052, a second 10/100/1000 Base-T AFE 1054, a third 10/100/1000 Base-T AFE 1056, a fourth 10/100/1000 Base-T AFE 1058, a single controller 1060, a register block 1062 and a selector block 1064. Selector block 1014 may be coupled to controller 1010 and selector block 1064 may be coupled to controller 1060. Notwithstanding, the invention is not limited in this regard and any of the selector blocks 1014, 1064 may be integrated within controllers 1010, 1060 respectively.

**[63]** For the first device 1000, channel A is cross-connected to media pair 2 and channel B is cross-connected to media pair 1. Channel C is cross-connected to media pair 4 and channel D is cross connected to media pair 3. For the second device 1050, channel A is also cross-connected to media pair 2 and channel B is cross-connected to media pair 1. Channel C is cross-connected to media pair 4 and channel D is cross connected to media pair 3.

**[64]** In operation, controller 1010 of device 1000 may determine a usable media pair from all existing media pairs, namely Pr 1, Pr 2, Pr 3 and Pr 4. The controller 1010 may be adapted to control selector block 1014 to select any one channel from all existing channels, namely Ch A, Ch B, Ch C and Ch D. The selector block 1014 may select the channel so that it is different from a general channel assignment corresponding to the determined usable media pair. A general assignment refers to Ch A being cross-connected to Pr 1, Ch B being cross-connected to Pr 2, Ch C being cross-connected to Pr 3 and Ch D being cross-connected to Pr 4. Selector block 1014 may be adapted to select a channel that may be assigned to a media pair. The controller 1010 may be configured to notify the second device 1050 of the assigned channel which corresponds to the media pair chosen from all the media pairs. Controller 1060 of the second device 1050 may be adapted to control selector block 1064 so that selector 1064 may cross-connect a corresponding channel and media pair, which is equivalent to the selected channel assigned to the media pair. In another aspect of the invention, controllers

1010, 1060 may be configured to negotiate with each other to determine a mutual assignment of the selected channel to any one of the media pairs. The selector block 1014 for device 1000 may select a particular one of the channel and media pair assignments which may be selected from a plurality of predetermined channel and media pair assignments.

**[65]** In one embodiment of the invention, a first combination of a previously assigned channel and media pair may be designated as a communication channel and media pair. Similarly, the second combination of the channel and the previously assigned media pair may be designated as a communication channel and media pair. For example, the channel A/media pair 2 and channel B/media pair 1 cross-connections for device 1000, collectively referenced as 1016, may be designated as the communication channel and media pair assignment. Likewise, the channel C/media pair 4 and channel D/media pair 3 cross-connections for device 1000, collectively referenced as 1018, may be designated as the control channel and media pair assignments. Additionally, the channel A/media pair 2 and channel B/media pair 1 cross-connections for device 1050, collectively referenced as 1066, may be designated as the communication channel and media pair assignment. Likewise, the channel C/media pair 4 and channel D/media pair 3 cross-connections for device 1050, collectively referenced as 1068, may be designated as the control channel and media pair assignments.

**[66]** The controllers 1010, 1060 may be configured to securely transfer communication traffic via the communication channel and media pair 1016, 1066. Similarly, the controllers 1010, 1014 may be adapted to securely transfer control information via the control channel and media pair 1018, 1068, or the communication channel and media pair 1016, 1066. The controller 1060 of device 1050 may be adapted to monitor the communication channel and media pair 1016 and/or the control channel and media pair 1018 in order to determine the selected channel and media pair assignment, which may be utilized by device 1000. The controller 1010 of device 1000 may also be adapted to monitor the communication channel and media pair 1066 and/or the control channel and media pair 1068 in order to determine the selected channel and

media pair assignment, which may be utilized by device 1050. The control information may include, but is not limited to, authentication information, encryption information, channel setup information, link provisioning and link maintenance information.

**[67]** In one embodiment of the invention, automatic media dependent interface reconfiguration and repair may be used to enhance the capabilities offered by auto-MDIX. In this regard, automatic media dependent interface reconfiguration and repair may extend the capabilities of auto-MDIX by allowing auto-MDIX to provide support for media pairs other than media pairs 1 and 2 and media pairs 2 and 4. Accordingly, auto-MDIX using automatic MDI reconfiguration and repair may permit reconfiguration of media pairs 1 and 3 and media pairs 2 and 4 for use by any of a plurality of channels.

**[68]** Since multiple transceivers may be implemented on a single PHY device, automatic MDI reconfiguration and repair may be flexibly integrated within a PHY device without requiring any additional premium chip real estate. For this reason, automatic MDI reconfiguration and repair may be adapted to utilize existing gigabit architectures without a need for extensive re-engineering which may be costly and time consuming. Additionally, existing PHY transceiver analog front ends (AFEs) utilized in Gigabit products have the capability to transmit and receive at, for example, 10 Base-T and 100 Base-TX on all pairs. Moreover, external components for gigabit products such as termination resistors and magnetics may be readily capable of transmitting and receiving 10 Base-T and 100 Base-TX on all media pairs. This makes automatic MDI reconfiguration and repair more desirable that any conventional system. Accordingly, supplemental hardware may be added or existing hardware may be augmented to arbitrarily switch channel assignments to any pair using automatic MDI interface reconfiguration and repair in accordance with the invention. Automatic MDI reconfiguration and repair may also permit detection of available media pairs and provide dynamic assignment of channels to the available pairs. In this regard, automatic MDI reconfiguration and repair may provide a flexible approach for facilitating full multiplexing of channel data to available media pairs.

**[69]** Accordingly, the present invention may be realized in hardware, software, or a combination of hardware and software. The present invention may be realized in a centralized fashion in one computer system, or in a distributed fashion where different elements are spread across several interconnected computer systems. Any kind of computer system or other apparatus adapted for carrying out the methods described herein is suited. A typical combination of hardware and software may be a general-purpose computer system with a computer program that, when being loaded and executed, controls the computer system such that it carries out the methods described herein.

**[70]** The present invention may also be embedded in a computer program product, which comprises all the features enabling the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer program in the present context means any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form.

**[71]** While the present invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present invention without departing from its scope. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed, but that the present invention will include all embodiments falling within the scope of the appended claims.